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(54) LASERS

(71) We, BOC INTERNATIONAL LIMITED (formerly THE BRITISH OXYGEN COMPANY LIMITED, of Hammersmith House, London W6 9DX, England, an English company, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to lasers, and in particular to high power carbon dioxide lasers.

The discharge tube of a carbon dioxide laser contains a mixture of helium, carbon dioxide and nitrogen. If the amount of either carbon dioxide or nitrogen in the tube becomes too low, the laser action will very quickly cease.

In the plasma formed in the laser tube, electrons will sometimes collide with the carbon dioxide molecules and cause them to dissociate into carbon monoxide and atomic oxygen both of which hinder the mechanism leading to laser action and cause a drop in laser power. The atomic oxygen is highly reactive and will quickly react with any impurities, with parts of the apparatus, such as the electrodes, or with the nirtogen to give various oxides of nitrogen, such as nitrous oxide and nitric oxide. This will result in a decrease in the amount of carbon dioxide and nitrogen in the mixture and, if nothing is done to replace them, laser action will soon stop.

One method of solving this problem is to vent the exhaust gas to the atmosphere and replace it with a fresh mixture of helium, nitrogen and carbon dioxide. However, this wastes a lot of expensive helium.

According to the present invention there is provided a gas laser system which is as claimed in any one of the appended claims.

It is an aim of the present invention to provide a laser system in which only some of the exhaust gas is vented to the atmosphere, the remainder being recirculated after having had at least some of the impurities removed.

It has been found that if the rate of flow of gas through the laser tube is sufficiently high, the percentage of carbon dioxide which dissociates before leaving the tube is so low that the build up in dissociation products is prevented even if only a small fraction of the circulating gas is passed through a reaction vessel.

The term "reaction vessel" is used in this specification to describe any vessel provided with means for reversing the dissociation processes occurring in the laser discharge tube, so that if the exhaust gases from the laser are passed through a reaction vessel, the gas mixture leaving the vessel contains less dissociation products than the gas mixture entering the vessel.

The invention will now be described, by way of example, with the aid of the accompanying drawing which shows in schematic form a gas laser of the present invention.

Gas is drawn out of laser discharge tube 1 through outlet passage 3 where it is cooled by a cooler 5. Most of the gas is drawn through Roots blower 7, flows along passages 9 and through coolers 11 and is recirculated to the laser tube 1. The pressure at which it re-enters the tube is controlled by valves or calibrated orifices 13. A small amount of the gas is drawn from outlet passage 3 through a reaction vessel 15, a cooler 17 and a filter 19 by a vacuum pump 21. The pressure of the gas passing through the reaction vessel 15 is the same as the pressure of the gas in the laser tube. Any oil or oil vapour contamination produced by the pump is removed by passing the gas through an oil trap 23 and an oil vapour trap 25. The gas

then flows into a reservoir 27 from which a small amount of the gas is allowed to vent to atmosphere. The gas then passes through a vessel 29 containing alumina balls, and into passages 31. Make up gas from cylinders 33 also flows into passages 31. The amount of gas from the reaction vessel 15 and the amount of make up gas from cylinders 33 which flows through passages 31 is controlled by valves or calibrated orifices 35. The gas mixture in passages 31 is allowed to bleed into passages 9 through valves or calibrated orifices 37.

In reaction vessel 15, the recombination of carbon monoxide and the oxygen and the removal of the oxides of nitrogen must be encouraged if the laser is to operate for long periods. In practice a single catalyst or reaction stage will not fulfil both the functions, so a mixed catalyst bed or a catalyst followed by a heated tube is necessary. A typical reaction vessel contains a ruthenium catalyst at a temperature of about 300°C, followed by a tube heated to about 700°C or an iron oxide/chromium oxide catalyst at 500°C.

Experiments have been done using apparatus of the type shown in the diagram, with the pressure of the gas in the discharge tube being in the range 30-40 Torr, instead of about 10-12 Torr which is the pressure usually used in the discharge tubes of known lasers. When about 2200 cu ft of gas was passing through the tube per minute, the flow was supersonic and it was found that only about 10% of the carbon dioxide dissociated during the passage through the tube, whereas, in known lasers up to 80% of the carbon dioxide may dissociate. It was discovered that under the conditions described above, even if only about 0.7% of the circulating gas was passed through the reaction vessel, an undesirable build up in the amount of dissociation products was prevented.

A laser of the present invention has the advantage over laser systems in which all the circulating gas passes through a reaction vessel that, even though the quantity of gas used is large, the amount of catalyst needed is relatively small.

WHAT WE CLAIM IS:

1. A gas laser system including a laser discharge tube, at least one main recirculation path for the laser gas medium and a reaction vessel through which exhausted gas medium is passed for treatment with a catalyst for reversing the dissociation of the gas medium occuring in the laser tube, the system including means for flowing the gas medium fast enough to minimize the said dissociation of the medium and means for diverting from the main recirculation path a minor portion of the gas medium exhausted from the discharge tube and for passing only that minor portion of gas through the said reaction vessel.

2. A gas laser system according to claim 1, in which the said diverting means comprises a vacuum pump located on a secondary recirculation path leading back to the discharge tube.

3. A gas laser system according to claim 1 or 2, in which the pressure in the discharge tube is 30 to 40 Torr.

4. A gas laser system according to claim 1, 2 or 3, wherein the means for flowing the gas medium is a positive displacement pump.

5. A gas laser system according to claim 4, wherein the positive displacement pump is one which is capable of passing 2200 cubic feet per minute of gas through the discharge tube.

6. A gas laser system according to claim 4 or 5, wherein the positive displacement pump is a Roots blower.

7. A gas laser system according to any preceding claim, in which a cooler is located at the outlet of the discharge tube upstream of the said diverting means.

8. A gas laser system according to any preceding claim, in which a valve or calibrated orifice is provided to control the pressure of gas entering into the discharge tube.

9. A gas laser system according to claim 8, in which a cooler is located upstream of the valve or calibrated orifice.

10. A gas laser system according to any preceding claim, in which an oil trap and oil vapour tray are connected in series downstream of the said diverting means.

11. A gas laser system according to any preceding claim, in which a reservoir is in communication with an outlet of the reaction vessel, which reservoir has two outlets, the first outlet being in communication *via* a conduit with the main recirculation path downstream of the said diverting means, and the second outlet being connected to atmosphere.

12. A gas laser system according to claim 11, in which a vessel containing alumina balls is located on said conduit downstream of the first outlet of the reservoir for passage of treated gas medium therethrough.

13. A gas laser system according to claim 12, in which a valve or calibrated orifice is provided in the said conduit downstream of the vessel containing alumina balls to control the pressure at which gas enters the conduit.

14. A gas laser system according to claim 12 or 13, in which gas cylinders containing nitrogen, helium and carbon dioxide are in communication with the said con-

duit, and in which valves or calibrated orifices are located between the cylinders and the conduit to control the pressure at which gas enters the conduit from the cylinders.

15. A gas laser system according to claim 12, 13 or 14, in which valves or calibrated orifices are located at the end of the conduit leading into the main recirculation path to control the rate at which gas enters the main recirculation path.

16. A gas laser system according to any preceding claim, in which the reaction vessel includes a ruthenium catalyst maintained at 300°C.

17. A gas laser system according to any preceding claim, in which the reaction vessel includes a tube heated to 700°C.

18. A gas laser system according to any preceding claim, in which the reaction vessel includes an iron oxide/chromium oxide catalyst at 500°C.

19. A gas laser system substantially as herein described with reference to, and as illustrated in, the accompanying drawing.

20. A gas laser including a discharge tube containing a gas mixture, the discharge tube having one or more inlets and an outlet, in which the outlet is in communication with the inlet of a positive displacement pump, of which the outlet is connected to the or each discharge tube inlet through one or more main conduits, and in which an inlet of a reaction vessel is in commmunication with the said discharge tube outlet, an outlet of the vessel being in communication with the inlet of a vacuum pump, of which the outlet is in communication with one or more of the said discharge tubes inlets.

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1 462 360 COMPLETE SPECIFICATION
1 SHEET This drawing is a reproduction of the Original on a reduced scale.